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P1.224

Preliminary accident analysis of ex-vessel LOCA for the European DEMO HCPB blanket concept

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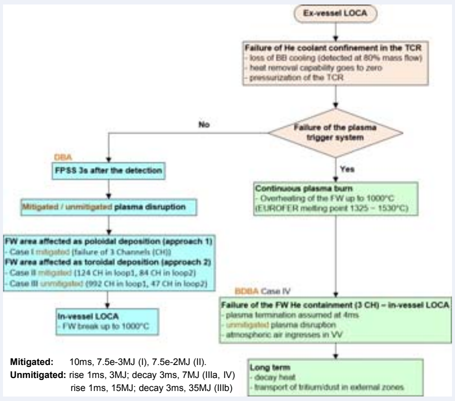
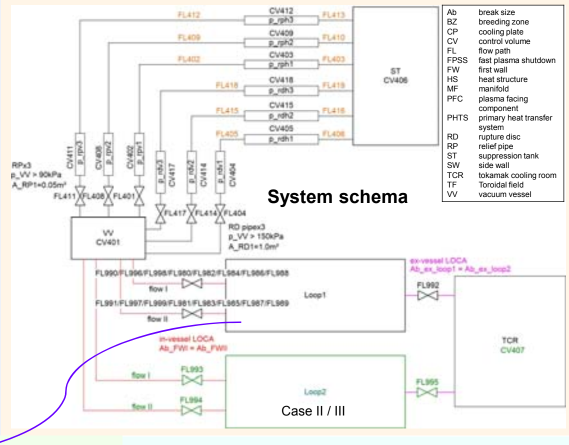
Evolution scheme of the ex-vessel LOCA



Modelling using MELCOR1.8.6 for fusion

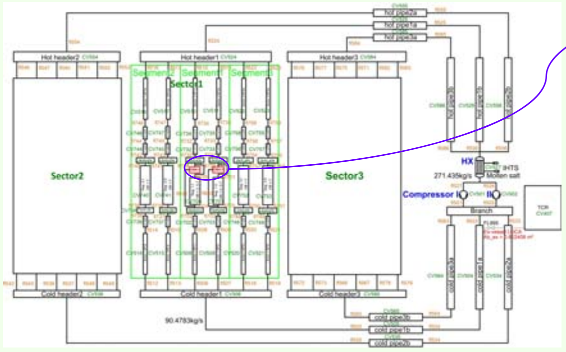


Reference design

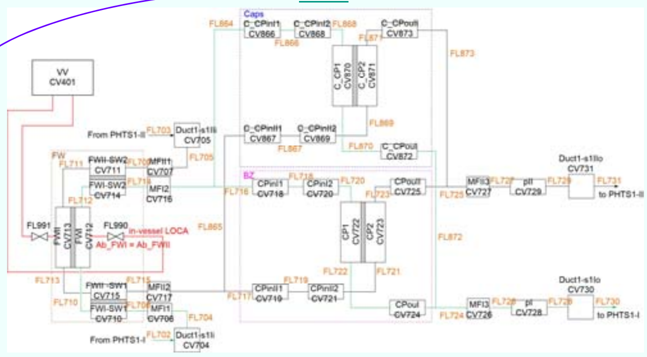
- DEMO baseline 2015 (18TF)
- HCPB2016 vs. HCPB2015V3
  - Double-caps at top and bottom: 42 cooling channels / CP, cross section 5mmx5mm
  - BZ: 42 cooling channels / CP , cross section 5mmx3mm, 60CPs
- PHTS for HCPB2015V3: inlet piping through the lower ports
- Parameters for the VV, ST and TCR:

Item	V [m³]	T [°C]	p [kPa]
VV	2502	300	0.1
ST_1 (dry)	50000	30	4.5
ST_2 (wet, air/water)	49900 / 100	30	4.5
1xRP (3x)	2.0	30	4.5
1xRD (3x)	40.0	30	4.5
TCR	60700	30	98.0

Loop1



OB4



CaseIVd

- Source terms
  - W-dust: 25kg & 5kg at disruption
  - Tritium: 351 ~ 2450g in PFC, 106.76g in BMs, 0.64g/loop.
- Results at t_{end} (volume & HS)
  - Dust: 29.9644kg in the VV, 4.78744e-3kg in the ST, not in the TCR.
  - Tritium: 2.4477kg in the VV, 5.1358e-4kg in the ST, 1.6135e-2kg in the TCR.

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Scenarios & time evolution in transient

Sequence		Time (s)							
Scenarios		I	II	IIIa	IIIb	IVa	IVb	IVc	IVd
FW failure size (m²)		0.01	1.0	5.0		0.01			
ST		ST_2				ST_1	ST_2	ST_1	
VV cooling		steady			controlled	steady	steady	controlled	steady
Emissivity		0.25			0.8	0.25			
He		NCG				WF	NCG	WF	
ex-vessel LOCA		0.0 (DEGB with 0.622408 m²)							
Detection of He blowdown (t_{sig})		0.0215	0.0217	0.0217	0.0219	0.0211	0.0215	0.0212	0.0212
FPSS (t_{sd_f})		3.0215	3.0217	3.0217	3.0219	-			
Compressor shutdown (t_{sd_c})						3.0211	3.0215	3.0212	3.0212
End of plasma disruption		3.0315	3.0317	3.0257	3.0259	-			
In-vessel LOCA (t_{fail})		16315.676	16160.924	16058.430	16869.387	133.6691	133.6554	133.7611	133.6711
End of plasma disruption		-				133.6731	133.6594	133.7651	133.6751
Open RP (t_{RP})		22540.832	16224.662	16058.430	16883.934	5352.6753	5346.8013	7562.5713	5352.7192
Open RD (t_{RD})		no							
Tritium / dust	VV	-							133.6731
	ST	-							5352.731
	TCR	-							0.0026 / -

Conclusion

- He inventory of two loops of 3.1696e3kg has impact on the pressurization of the TCR, the VV and the ST. A pressure peak in the TCR of 1.64465e5 Pa is 25.81% higher than it from one loop.
- In-vessel LOCA at ~134s due to the BDBA; it is postponed to ~4.46h in the DBA.
- Remove the excessive power in the VV during the in-vessel LOCA, T_{VV} can retain at T_{OB_in}, and the in-vessel LOCA is delayed.
- The VV pressure increased to the system equilibrium level is less than p_{VV_RD}, thus the RD is closed all the time.
- Temperature can be reduced effectively in the wet ST.
- For the small break size, the most dust and tritium stay in the VV. Dust is not transported to the TCR.
- Next steps: detailed VV model for effective heat removal; in-vessel LOCA for large failure size in two loops; and source terms transport for the max. releases.

Transient